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(73) Owner:
D.T.S. Gesellschaft zur Fertigung von Dünnschicht-Thermogenerator-Systemen mbH, 06118 Halle, DE
(D.T.S. Corporation for manufacture of thin-film thermal generator systems)

(74) Agent:
Voigt, W., Ing. Pat.-Ing., Patent Attorney, 06108 Halle

(54) Compact low-power thermal generator

Compact low-power thermal generator

The invention relates to a compact, low-power thermal generator in thin-film or thick-film technology as an independent energy source to supply micro and optoelectronic circuits, components and sensors as well as microsystemic applications.

Miscellaneous compact low-power thermal generators are known from prior art. Low-power thermal generators have in common that a plurality of thermocouples are applied on a film or another thin insulating material in thin-film or thick-film technology.

According to DE-OS 24 57 586, a strip prepared in this way is folded several times between heat exchanger plates. The strip cannot be sharply folded to any extent, because the reliability of the thermal generator is reduced above a specific packing density.

In WO 89/00152, the thermocouples are deposited in a sinuous pattern on a film strip. The film strip is rolled up. Rolling up with any given small bending radius is not possible, however, since the strip cannot be sharply bent to any extent, because this will subject the thermoelectric layers to high mechanical loading, which produces a drastic increase in its electrical resistance and/or said layers are destroyed by micro cracks.

Reference should also be made to DE-GM 69 00 274. According to this publication, a number of films with thermocouples are assembled as a stack. Stacking the films solves the problem of destroying the thermocouples through the formation of cracks, compared to the above-mentioned patent applications. However, if many films (for example 100 films) are assembled as a thermal generator sized 0.2 cm^3, a new problem results, i.e. one of exact through-contacting.

The object of the invention thus is to increase the reliability of the thermal generator, assuming a high packing density.

The objective in accordance with the invention is achieved, wherein reference is made in Claim 1 to the underlying ideas. The further development of the invention is shown in the sub-claims. Concerning the essence of the invention, reference is also made to the exemplary embodiments and the subsequent explanations.

Several films (or similar thin insulating substrates with very poor thermal conduction, hereafter named films) coated with thermocouples, contacts and metallized surfaces are tightly stacked on top of each other and are electrically connected with each other. In order to achieve long service life of the component in a stack having high packing density with a plurality of contacts (depending on how many films are stacked on top of each other; approximately 100 films), reliable through-contacting is particularly important. A connection of the contact surfaces is made with electrically conductive adhesive or solder, whereby the contact surfaces are provided with semicircular apertures, so-called openings. The inside walls of the openings can be metallized by means of sputter technology. Using the above-mentioned adhesive or solder thus ensures a secure contact.

The metallized surfaces applied on the films have the function to make the geometrical and thermal conditions on a film symmetrical, i.e. the films including the coating have the same thickness on both of their long front faces, whereby adhesive can also be provided to the metallized surfaces, which during stacking results in a homogenous stack height.

When using thermoelectric highly effective materials of the bismuth telluride type, which are deposited on the substrate film by means of flash evaporation or sputtering, a Seebeck coefficient of approximately 400 μV/K per thermocouple for the p-type and d-type legs of the photolithographically structured thermocouples can be achieved.
At a 10 K temperature difference, a voltage of approximately 3 V and a power of roughly 10 μW can be achieved in case of electrical adaptation with such approximately 0.2 cm^3 sized thermal generator as taught by the invention.

With these voltages, the thermal generator is electrically directly or through electronic coupling systems compatible with microelectronic circuits.

The invention is subsequently illustrated in detail using several exemplary embodiments in the drawings as follows:

Fig. 1 shows a compact low-power thermal generator as taught by the invention

Fig. 2 shows a film A provided with thermocouples on one side

Fig. 3 shows a film C

Fig. 4 shows a film D

Fig. 5 shows the structure of a thermal generator as taught by the invention made up of films as they are illustrated in Figures 2 – 4 (the thermocouples are not drawn here)

Fig. 6 shows the fronts of three films coated with a single layer of thermocouples of a thermal generator according to Fig. 5

Fig. 7 shows the fronts and the backs of three consecutive films coated with thermocouples on one side for a thermal generator as taught by the invention

Fig. 8 shows the fronts and the backs of three consecutive films coated with thermocouples on both sides for a thermal generator as taught by the invention

Reference legend:

1	Polyimide film - as general description
2	Heat exchanger plates
3	Connection wires
4	Thermocouple
4’	p-type conducting leg of the thermocouple
4’’	n-type conducting leg of the thermocouple
4’’’	Metal bridge
5.5’	Contact surfaces
6.6’	Contact surfaces
7.7'	Metallized surfaces

8 Conductor of film C
9 Conductor on front VS of film D
10 Conductor on back RS of film D
11 Openings

Film types A, B, C, D, are referred to as special film types of the thermal generator, where the type designations are not to be understood as reference characters. With films C, D, this involves films on the outside of the thermal generator, while the films A, B in the thermal generator are arranged between films C, D.

On a polyimide film (1), equivalent structures to Figures 2 to 4 are deposited in thin-film technology: thermocouples (4), contact surfaces (5, 5', 6, 6'), metallized surfaces (7, 7') and conductors (8, 9, 10). Each thermocouple consists of the p-conducting leg 4', the n-conducting leg 4", and the metal bridge 4'''.

According to Fig. 5, the films from type A and from type B (B is structured as a mirror image of A) are alternately stacked on top of each other and are closed on the outside with a film of type C and/or D. According to Fig. 1, the film pack is manufactured with heat exchanger plates 2 and connection wires 3, which have electrical contact with conductors 8, 9 and 10. The heat exchanger plates are connected with the long front sides of films 1 with an adhesive that has good thermal conductivity, which is not represented.

In a first embodiment (Figures 2 to 6), the films 1 are coated only on one side on the front with thermocouples 4. Each strip from these thermocouples 4 each has two contact surfaces 5 and 6, also on the front. The thermocouples 4 between contacts 5 and 6 are connected in series. The contact surfaces 6 and the film behind it are perforated. Toward the upper edge of the film is an approximately semicircular aperture, referred to as opening 11.
The inside walls of the openings 11 can be metallized by means of sputter technology. The contact surfaces 6 of the films A, 5 of the films B and/or 6 of the films B, 5 of the films A are through-contacted with electrically conductive adhesive or solder. Metallized surfaces (7) are applied on the front of films (1).
Fig. 5 shows a series connection diagram in which the films 1 are configured alternatively A-B-A-B.

A second embodiment according to Fig. 7 differs from the first in that also contact surfaces 6' and metallized surfaces 7 are located on the backs of films 1. Figure 7 illustrates the fronts and backs VS and/or RS of three consecutive films A-B-A. The lower section of each of the fronts is shown in top view. The backs are opened to the top in the plane of projection, i.e. so that the upper edges of the fronts and backs contact each other. (An equivalent illustration was also selected for Figure 4)

The reliability of through-contacting is increased to an even greater extent in the second exemplary embodiment in that the contact surfaces 6' are likewise connected by metallizing the backs of films A and B to the contact surfaces 5 which are positioned behind the stack with electrically conductive adhesive or solder. In addition, the inside walls of openings 11 can also be metallized here.

A third embodiment differs from the previous one in that the thermocouples 4 are located on the front and back of films 1 and are configured so that thermocouple legs of different conductor types are connected with the contact surfaces 5 and 5' and/or 6 and 6'. See also Figure 8.

The stacking and contacting is initially done as described in the second embodiment and is supplemented here by an additional electrically conductive connection, which is likewise realized by means of electrically conductive adhesive or solder, between the contact surfaces 5' of the films A and 6 of the films B and between 5' of the films B and 6 of the films A.

This results in that the thermocouple chains from the back and front of adjacent films are electrically connected in parallel in the stack sequence A-B-A, while the films are electrically connected to each other in series.

Due to their function, the films in this exemplary embodiment must be provided with an insulating layer such as varnish or high temperature photoresist, except for the electrical contact surfaces 5, 5', 6, 6'.

Compared to the first two exemplary embodiments, the electrical resistance decreases with this arrangement, and the power output of such thermal generator is even increased under otherwise identical conditions, whereby the packing density can also be increased. A low-power thermal generator in this embodiment is highly reliable, because a break in one thermocouple leg does not result in failure of the component because of the existing redundancy.

Claims

1. Low-power thermal generator, in which each of the thermocouples consist respectively of one p-type conducting and one n-type conducting leg of thermoelectric material, where the two legs are connected to each other in a sinuous pattern through a metal bridge, the thermocouples and the contact surfaces are placed on insulating films, the films are so arranged that they form a stack and where the heat exchanger plates in a stack made up of rectangular films are connected to the long front sides of the films, characterized in that the thermocouples (4) and metallized electrical contact surfaces (5, 6) are each arranged on the front of a film (1), where the contact surfaces (5, 6) of a film (1) are connected to the contact surfaces (5, 6) of adjacent films (1) via through-connections by means of electrically conductive connecting materials.

2. Compact low-power thermal generator according to Claim 1, characterized in that respectively one additional metallized contact surface (6') on the back of the films (1) is congruently arranged with the respective contact surface (6) on the front of the films (1).

3. Compact low-power thermal generator according to Claim 1, characterized in that the thermocouples (4) on the front and on the back of the films (1) are arranged with contact surfaces (5, 5', 6, 6'), in which the contact surfaces (5', 6') on the back of the films (1) are congruent with the contact surfaces (5, 6) on the front of the films (1).

4. Compact low-power thermal generator according to Claim 1 to 3, characterized in that in the arrangement of the contact surfaces (5, 5', 6, 6') on the films (1) metallized surfaces (7, 7') are additionally deposited in a manner that on the respective sides of the films (1) during the assembly of the films (1), the geometrical and thermal conditions on the films (1) are symmetrically arranged through the stacking of said films.

5. Compact low-power thermal generator according to Claim 1 and 4, characterized in that respectively one electrical connection of three consecutive films (1) is made up with the stack sequence A-B-A, whereby the electrical connection is made through the contact surfaces (6) of the films A, (5) of the films B, (6) of the films B, (5) of the films A, whereby the connections (6) of the films A to (5) of the films B and/or (6) of the films B to (5) of the films A are through-connections.

6. Compact low-power thermal generator according to Claim 1, 2 and 4, characterized in that respectively one electrical connection of three consecutive films (1) is made up with the stack sequence A-B-A, whereby the electrical connection is made through the contact surfaces (6) of the films A, (6') of the films A, (5) of the films B, (6') of the films B, (5) of the films A, whereby the connections (6) of the films A to (6') of the films A to (5) of the films B and (6) of the films B to (6') of the films B to (5) of the films A are through-connections.

7. Compact low-power thermal generator according to Claim 1, 3 and 4, characterized in that respectively one electrical connection is made up of three consecutive films (1) and the stack sequence A-B-A, whereby the electrical connection is made through the contact surfaces (6) of the films A, (6') of the films A, (5) of the films B, (6) of the films B, (6') of the films B, (5) of the films A, and an additional electrical conductive connection between the contact surfaces (5') of the films A and (6) of the films B and between (5') of the films B and (6) of the films A are connected in parallel and the films (1) are provided with an insulating layer.

8. Compact low-power thermal generator according to Claim 1 to 7, characterized in that the contact surface of the film type D and the contact surfaces (6) and/ or (6') of the film type A, B are provided with openings (11) which are open toward one side of a film edge and the openings (11) are filled with an electrically conductive adhesive or solder.

9. Compact low-power thermal generator according to Claim 1 to 7, characterized in that the contact surfaces (5, 5', 6, 6') are coated with electrically conductive adhesive or solder.

Fig. 1

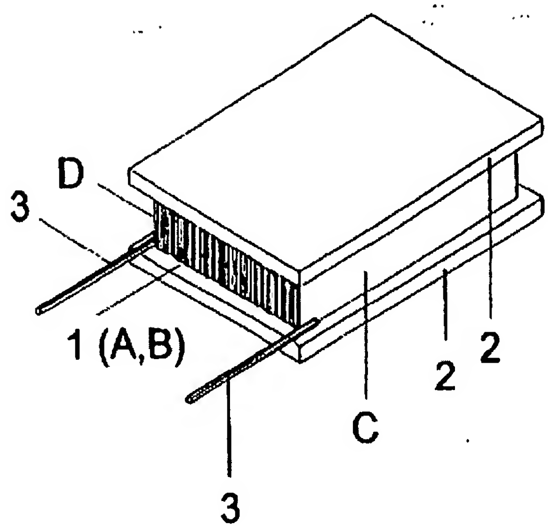

Fig. 2

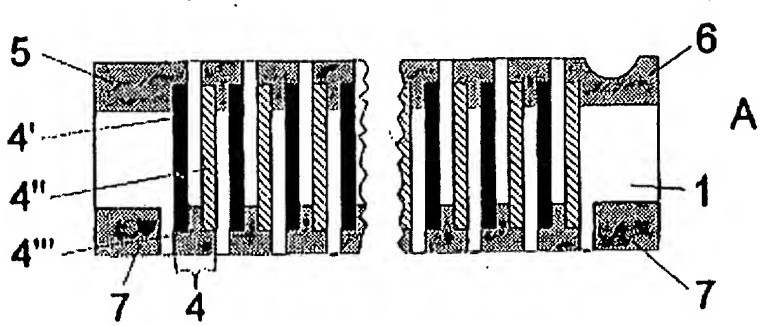

Fig. 3

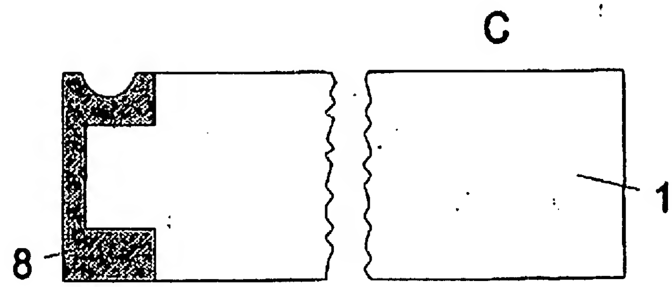

Fig. 4

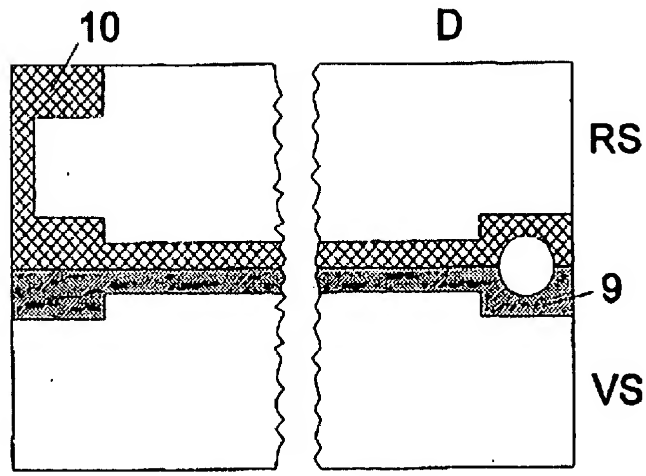

Fig. 5

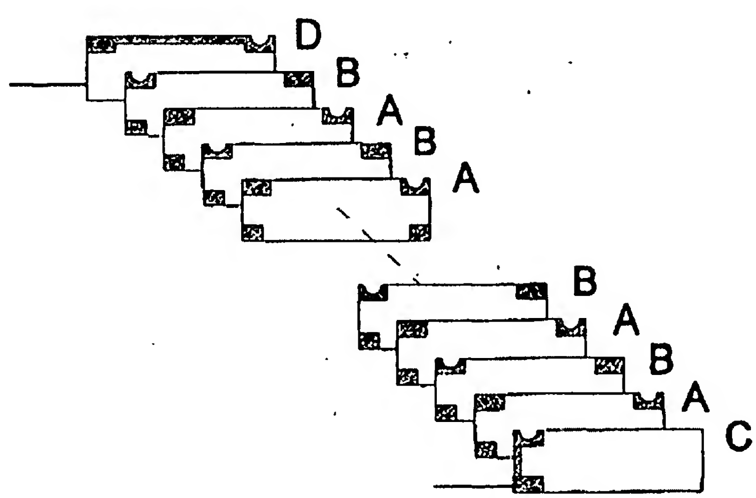

Fig. 6

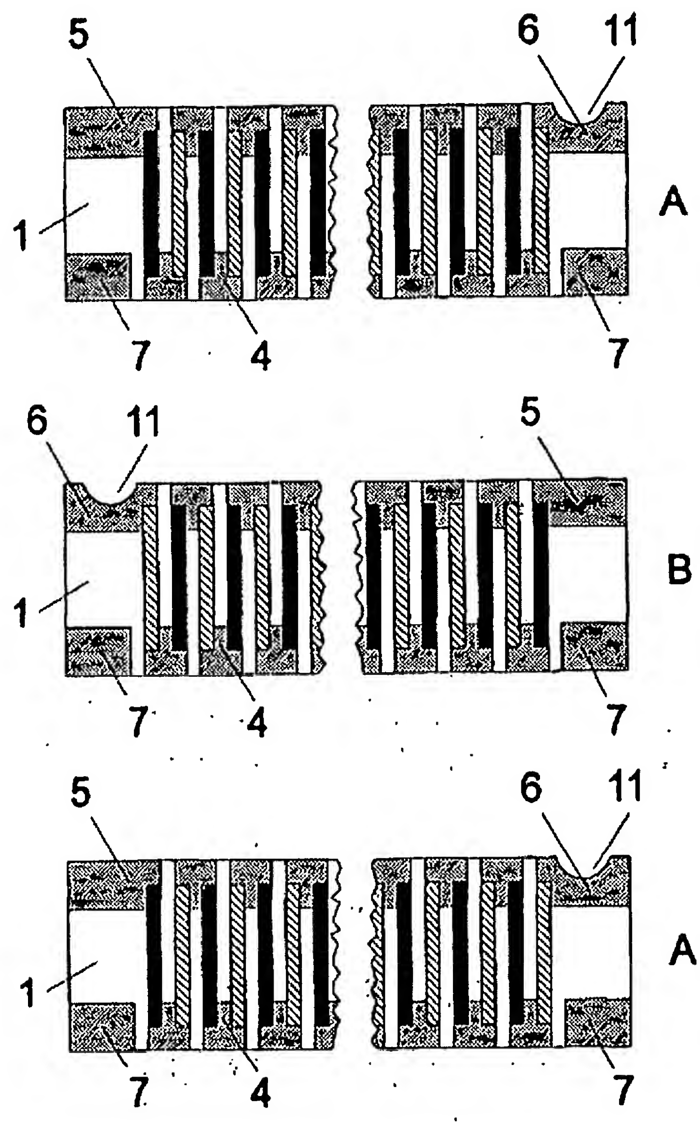

Fig. 7

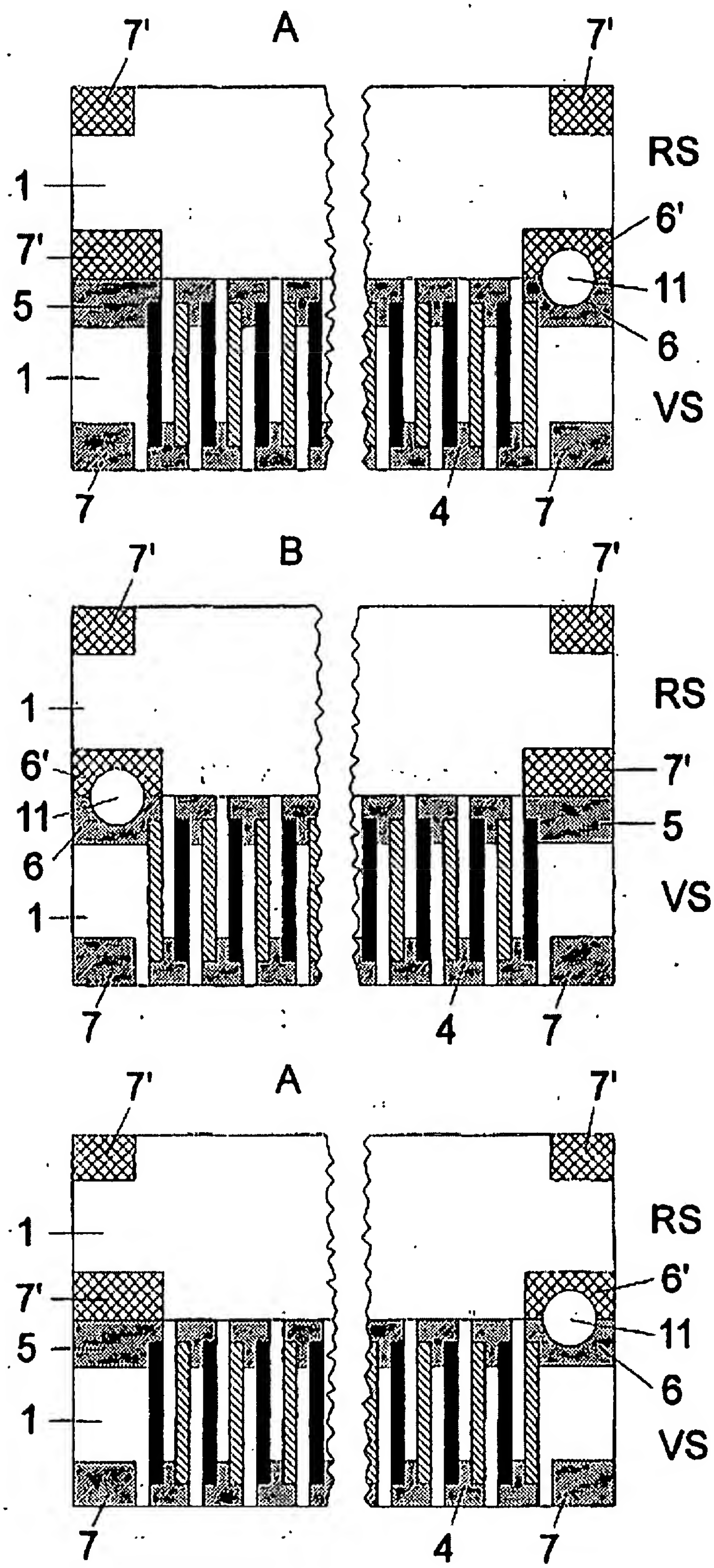
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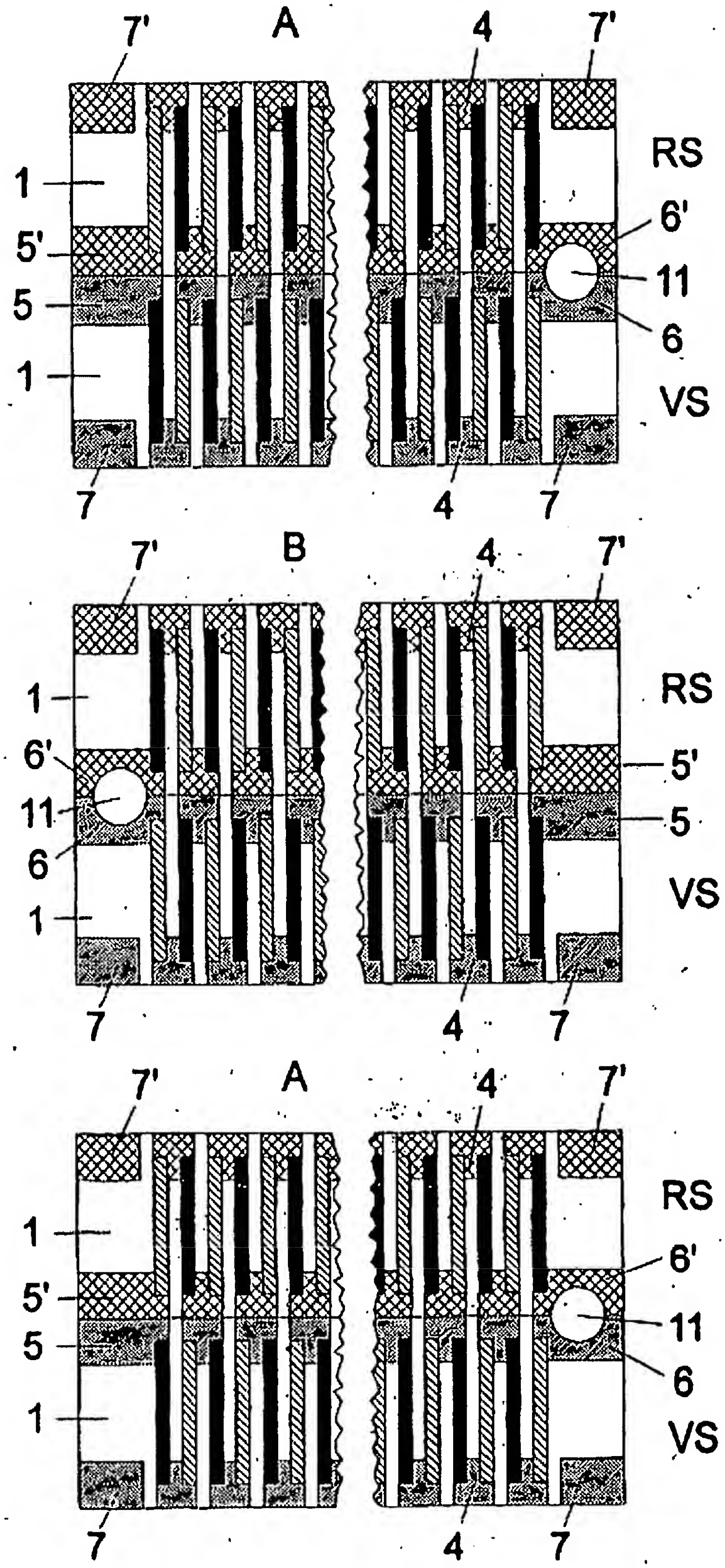
Fig. 8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